AD-A094 647 NATIONAL NAVAL DENTAL CENTER BETHESDA MD F/G 11/6
PHYSICAL PROPERTIES OF A REPEATEDLY USED NONPRECIOUS METAL ALLO--ETC(U)
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TECHNICAL REPORT

PHYSICAL PROPERTIES OF A REPEATEDLY USED NONPRECIOUS METAL ALLOY

by

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ADMINISTRATIVE INFORMATION

This study was sponsored and supported by the Bureau of Medicine and Surgery under Naval Medical Research and Development Command Research Work Unit No. M0095-PN.04-314.

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Reprinted from THE JOURNAL OF PROSTHETIC DENTISTRY, St. Louis
Vol. 44, No. 3, Pages 291-293, September, 1980 (Printed in the U. S. A.)

Physical properties of a repeatedly used nonprecious metal alloy

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In our current economy it is obligatory that dentists and technicians be cost conscious about the materials they use for fixed prostheses. The preferential use of the precious metal alloys has almost been eliminated by the elevated costs of all precious metals. The subsequent demand for semiprecious and nonprecious base alloys in dental procedures has now resulted in substantial increases in the price of these once insignificant alloys, again to a point of financial concern.

The original nonprecious metal alloys introduced into dentistry 15 to 20 years ago were so inexpensive that the new ingots were melted, cast, and discarded or sold back to the supplier by the pound as scrap, even though they were purchased by the pennyweight or ounce. When using the inexpensive nonprecious alloys, technicians used all new metal for each casting instead of mixing new metal with previously melted ingots.

With the increased costs of the nonprecious metals, it would be economically advisable to reuse them in combination with new metal, as is the practice when using precious metal alloys.[1, 2] Some laboratories combine one-half new with once-used nonprecious metal, and then all is discarded. However, the nonprecious metals might be reused several times with the addition of one-third or one-half new metal each time. Although there have been several reports on the repeated usage of precious metals and the evaluation of their physical properties, there are few reports available on the evaluation of the physical properties of nonprecious alloys after repeated use. Some properties that should be evaluated are hardness, tensile strength, yield strength, modulus of elasticity, coefficient of expansion, grain size, and percentage of elongation.

Many questions about these properties must be answered. For example, will the manufacturers' stated desired properties for a casting be adversely altered if the alloys are subjected to repeated melting temperatures? Will the addition of certain amounts of new metal to the total melt of previously melted ingots influence the physical properties of the resultant metal alloy? What is the optimum ratio of new and old metal combinations for consistent results?

This study was undertaken to evaluate hardness, tensile strength, and percentage of elongation of a nonprecious metal alloy used repeatedly for fixed partial denture castings. These physical properties were compared between single-melt alloy castings and second-, third-, and fourth-generation-melt alloy castings.

MATERIALS AND METHODS

A nonprecious metal* routinely used in U.S. Navy clinical laboratories was selected for evaluation.

Tensile test specimens were cast in accordance with ADA specification No. 14 for dental chromium-cobalt casting alloy (Fig. 1). A split brass mold† was

The opinions and assertions contained herein are the private ones of the writers and are not to be construed as official or as reflecting the views of the Department of the Navy.

Supported through funds provided by the Bureau of Medicine and Surgery under Research Work Unit No. M0095-PN.04-314.

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†Sherwood Research, Silver Spring, Md.

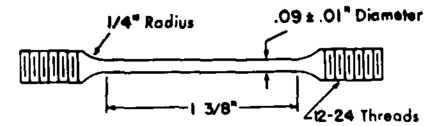

Fig. 1. ADA specification No. 14 for the tensile bar.

Fig. 2. *Wax sprue and tensile bar.*

made to comply with this specification, requiring a tensile bar 1⅜ inches long with a diameter of 0.09 ± 0.01 inches and 12 to 24 threads at each end with a ¼ inch radius of curvature connecting the bar and the threaded portion. The sprue portion was formed in a separate split brass mold. The wax sprue and tensile bar are shown in Fig. 2.

A commercial wax injector* was used to transport the molten wax to the heated, lubricated mold. Without the use of the wax injector, voids consistently occurred in the pattern. The pattern was invested in gypsum-bonded, low-heat investment.† The investment was painted on the pattern and allowed to dry for 9 minutes, then invested in a 500 gm casting ring. The ring was allowed to set for 1 hour, then placed in a cool oven. Burnout temperature of 1,350° F was reached by using a slow-heat oven‡ and the ring was heat soaked at this temperature for 3 hours.

An induction coil crucible assembly§ was used for the casting procedure. This eliminated carbon contamination of the metal that could result if a torch were used. Nine ingots of the alloy weighing 3.5 dwt per ingot were used for each casting. When the recommended casting temperature was reached, the motor-driven casting arm was rotated for 30 seconds. Following casting, the ring was allowed to bench cool overnight. The investment was removed, and the casting was cleaned with aluminum oxide abrasive powder.*

Tensile strength measurements were determined for each specimen according to ADA specifications by means of an Instron Universal testing machine.† A measuring microscope‡ was used to determine the percentage of elongation, and a testing instrument§ was used to measure hardness.

Following the tests for physical properties, the sprue and tensile bar were melted, cast a second, third, and fourth time, and measured in the same manner as described previously. Approximately 12 castings were made for each generation of castings.

RESULTS

The physical properties of the repeated castings for the first, second, third, and fourth generations, as compared with the minimum ADA specifications for chromium-cobalt alloys, are shown in Table I.

The hardness number was within the minimum ADA specification of 50 for the first generation and appeared to decrease slightly in the second, third, and fourth generations. However, statistical comparisons of the first through fourth generations showed no significant differences ($p > .05$ by the Student t test).

The tensile strength of each generation was under the minimum ADA specification of 6,300 kg/cm. When statistical comparisons were made between the tensile strength of the first through fourth generations, there were no significant differences ($p > .05$ by the Student t test).

The percentage of elongation was well above the minimum of 1.5% for all the generations. Although results appeared to vary considerably, which is in agreement with Harcourt's[3] findings, no significant differences were found between percentage of elongation values ($p > .05$ by the Student t test).

By the fourth generation, it was generally noted that insufficient metal was available for complete castings. These incomplete castings were not included in fourth-generation testings.

*Hydrolic Injector, M-3, 1 Qt., Casting Supply House, Inc., New York, N. Y.
†Investec, Ticonium Co., Inc., a division of CMP Industries, Albany, N. Y.
‡Ti-Controller, Ticonium Co., Albany, N. Y.
§Ticomatic, Ticonium Co., Albany, N. Y.

*Ticonium Co., Inc., a division of CMP Ind., Albany, N. Y.
†Instron Corp., Canton, Mass.
‡Measuring Microscope, Gaertner Scientific Corp., Chicago, Ill.
§Rockwell Superficial Hardness Tester, Wilson Mechanical Instrument Co., Bridgeport, Conn.

Table I. Physical properties of repeated castings with mean and SD values

Generation time	Hardness* (Rockwell 30N)	Tensile strength* (kg/cm²)	Percentage of elongation*	No. of samples per generation
First	50.6 ± 1.1	3,364 ± 1,117	2.4 ± 1.5	12
Second	49.3 ± 8.7	3,316 ± 774	3.3 ± 2.8	12
Third	46.1 ± 8.2	2,869 ± 697	2.1 ± 3.2	10
Fourth	46.3 ± 6.2	3,924 ± 922	6.8 ± 4.0	7
ADA	50	6,300	1.5	

*Differences between the generation times were not significant ($p > .05$ by the Student t test).

DISCUSSION

The findings showed no significant differences between the four generations of castings for any of the physical properties tested.

Although the hardness and tensile strength test results did not show a significant difference between casting generations, the measurements were below minimum ADA specifications. A possible explanation for the decreased tensile strength might be attributed to the difference in the size of the sprue and the tensile bar, which would cause the bar to become prestressed during cooling. A different type of sprue was designated for use in the ADA specifications. In this study, it was necessary to use a larger sprue to have sufficient metal for repeated castings. Another possible explanation for decreased tensile strength might be the procedure of premelting the metal prior to casting. However, if this were the case, a significant decrease in each generation cast would be expected. No decrease occurred.

The finding of no significant difference in the four generations is of clinical importance. This indicates that the metal can be recast for four generations with no alteration in the tensile strength, hardness, and percentage of elongation. It also indicates that the procedure of adding varying amounts of new metal to old, as suggested by the manufacturer, is not necessary.

Before a definitive recommendation can be made for repeatedly using nonprecious metals, further investigation is needed on other physical properties not evaluated in this study. These properties include the modulus of elasticity, grain size, carbide spacing, coefficient of expansion, and yield strength. The bond strength of porcelain-to-metal after repeated castings should also be examined.

The apparent variations that occurred among the four generations may be due to microporosity in the casting. The cross-sectional area of the casting is reduced by the amount equal to the area of the defect. Therefore, the tensile strength and percentage of elongation would be reduced in these areas much before any other area of the bar. X-ray inspection of the test castings could be used to detect subsurface porosity.[1] If any specimens were found to have porosity, they could be eliminated from the study.

SUMMARY

Some physical properties of nonprecious alloys were compared after repeated casting without the addition of any new alloy. The tensile strength, percentage of elongation, and hardness properties were determined and compared. There were no significant differences observed in the physical properties tested among any of the four generations of casting. This finding indicates that the metal can be reused for at least four generations.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A094 647	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) PHYSICAL PROPERTIES OF A REPEATEDLY USED NONPRECIOUS METAL ALLOY		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER TR-055
7. AUTHOR(s) Donald A. Hesby, Commander, DC, USN; Peter Kobes, Commander, DC, USN; Don G. Garver, Captain, DC, USN; and George B. Pelleu, Jr., Ph.D.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Naval Dental Center Bethesda, Maryland 20014		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS M0095-PN.04-314
11. CONTROLLING OFFICE NAME AND ADDRESS Chief, Bureau of Medicine and Surgery (MED 04) Navy Department, Washington, D.C. 20372		12. REPORT DATE 30 January 1981
		13. NUMBER OF PAGES 3
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Alloys, reuse of
Chromium-cobalt alloys
Dental materials
Physical properties

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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